Self-Screened Parton Cascades *

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Most recent theoretical predictions for the initial conditions at which a thermalized quark-gluon plasma will be produced at heavy ion colliders are based on the concept of perturbative partonic cascades. The parton cascade model starts from a relativistic transport equation of the form

$$p^\mu \frac{\partial}{\partial x^\mu} F_i(x,p) = C_i(x,p|F_k) \quad i = q, g, \qquad (1)$$

where $F_i(x,p)$ denote the phase space distributions of quarks and gluons. The collision terms C_i are obtained in the framework of perturbative QCD from elementary $2 \to 2$ scattering amplitudes allowing for additional initial- and final state radiation due to scale evolution of the perturbative quanta. To regulate infrared divergences, the parton cascade model requires a momentum cut-off for the $2 \to 2$ scattering amplitudes (usually $p_T^{\rm min} = 1.5-2$ GeV/c) and a virtuality cut-off for time-like branchings ($\mu_0^2 = 0.5-1$ GeV$^2/c^2$).

The high density of scattered partons in A+A collisions makes it possible to replace the arbitrary infrared cut-off parameters $p_T^{\rm min}$ and μ_0^2 by dynamically calculated medium-induced cut-offs. The dynamical screening of color forces eliminates the need for introduction of the momentum cut-off $p_T^{\rm min}$, and the suppression of radiative processes provided by the Landau-Pomeranchuk-Migdal effect makes the virtuality cut-off μ_0^2 unnecessary. Note that the viability of this concept crucially depends on the high parton density achieved in nuclear collisions. The dynamical cut-off parameters must lie in the range of applicability of perturbative QCD. Since the density of initially scattered partons grows as $(A_1 A_2)^{1/3}(\ln s)^2$, this condition requires both large nuclei and high collision energy. The calculations indicate that this criterion will be met at RHIC and LHC but not at the presently accessible energies of the SPS and AGS. The framework is also not applicable to pp or $p\bar{p}$ collisions at current energies because the parton density remains too low.

A semiclassical estimate of the screening requires that different scattering events can be treated as incoherent. This condition is satisfied if the produced partons, which screen other softer interactions, can be treated as on-shell particles. This requires that the transverse distance $\Delta x_\perp$ between the two scatterings must be larger than the interaction range of the two hard scatterings which are determined by the off-shellness of the exchanged gluons. We are thus led to consider

$$\tau_f(p_T) = \frac{a\hbar}{p_T} \qquad (2)$$

as the formation time of the produced partons in the mid-rapidity region from the hard or semi-hard scattering after which they can be treated as real (on-shell) particles and can screen other interactions with smaller transverse momentum transfer. The dimensionless coefficient a of order unity parametrizes our uncertainty of the precise formation time.

In order to estimate the effect of this screening on the parton scatterings with smaller p_T, we use the computed electric screening mass as a regulator for the divergent $\hat{t}$- and $\hat{u}$- channel sub-processes. We will simply make a replacement $\hat{t}(\hat{u}) \to \hat{t}(\hat{u}) - \mu_D^2$ in the minijet cross sections used in (**??**). In this way, by feeding the p_T-dependent screening mass back into the equation that defines it, we obtain self-consistent equations for the screening mass and the differential minijet cross section. These equations can be solved numerically by starting at a large p_T with no screening and then integrating down to smaller p_T.

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